

Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 731 597 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication: 11.09.1996 Bulletin 1996/37

(51) Int. Cl.6: H04N 1/405

(21) Application number: 96102365.2

(22) Date of filing: 16.02.1996

(84) Designated Contracting States: **DE FR GB**

(30) Priority: 21.02.1995 JP 57933/95

(71) Applicant: Dainippon Screen Mfg. Co., Ltd. Kamikyo-ku Kyoto 602 (JP)

(72) Inventors:

· Sano, Hiroshi, c/o Dainippon Screen Mfg. Co., Ltd. Horikawa-dori, Kamikyo-ku, Kyoto (JP) · Hirawa, Takahide, c/o Dainippon Screen Mfg Co, Ltd Horikawa-dori, Kamikyo-ku, Kyoto (JP)

· Nakamura, Yasunori, Dainippon Screen Mfg Co, Ltd Horikawa-dori, Kamikyo-ku, Kyoto (JP)

(74) Representative: WILHELMS, KILIAN & PARTNER Patentanwälte **Eduard-Schmid-Strasse 2** 81541 München (DE)

(54)Method and apparatus for generating halftone image

A plurality of correction look-up tables are prepared corresponding to offsets of halftone dot areas. An offset of a halftone dot area including the subject pixel is calculated, and a correction look-up table specified by the offset is selected in order to correct an input density value. Threshold values read out from an SPM (screen pattern memory) 130 may be corrected instead. Alternatively, a plurality of SPMs are prepared, each of which stores corrected threshold values corresponding to each offset, and an appropriate SPM is selected according to the offset. Accordingly, halftone dots are generated to faithfully reproduce a desired tone specified by multi-tone image data.

Description Tailous States Control of the Control of Co

erT area stem erain, sees to entitlining a Field of the Invention millionaeth is use with a cose is entitled to expend a reuneaether took our call med

The present invention relates to a method of general of ating a halftone image based on multi-tone image datas and also to an apparatus for the same: As box as how many method of the same of the sam

is exect or secretary from the earth of being or an app Description of the Related Artheoret, so hamples, tedaes the enemi

The halftoning technique expresses the density of an image by a dot percention a great rate of a halftone) and dot. An arrangement of shalftone dots, in an halftone was image, is defined by a screen ruling (or a pitch of half-utom tone dots) and a screen angle (or an angle of the dot a to arrangement relative to a scanning direction). The consumer ventional shalftoning technique applies ad constants to screen ruling over the entire image, and thus the rough and ruling arrangements of the image is controlled by the screen that ruling arrangement is a primary or to are a groupe and the screen are ruling arrangements.

Intecolor-printing technique, an original color image that is separated into four primary colors to generate fourth primary color esparation in halftone, images. The relationship as among the halftone dot arrangements of the four color upon separations, that is, the relationship between the four is sets of the escreent angle and the escreent ruling, visually extremely important in high-quality printing. Especially into a sequired that the screen angles of the four color septendal arations are exactly set to predetermined values or beauted.

There are two typical methods applied to generate sens halftone dots: Rational Tangent Method in which a tan- xoo' gent of screen angle θ (tanθ) is a rational number; and eatho Irrational Tangent Method in which an tangent of screen than angle θ is an irrational number. The Rational Tangent elds: Method does not allow the user to set an arbitrary. screen-ruling but generates halftone images having a flum predetermined, screen oruling a specified abylia appreset(a) M. threshold matrix. The Irrational Tangent Method, on the 140 other hand can adjust the screen ruling by selectively though reading out some threshold values from acthreshold elder matrix while skipping others according to the screentrule mod ing. Thus, the Irrational Tangent Method can set an arbi-lenor trary screen and an accurate screen angle by acas varying the way of reading out threshold values from anoma threshold;matrix.bins ir are tob enobled dose entitle process

Figs. 1(A) through 1(C) show a process of general-legal ing halftone dots by the trrational Tangent Method. Fig. 3. 1(A) shows a 128x128 matrix including threshold values in a range of 0 to 16383. A rhombic area on the center of Fig. 1(A) is defined by the threshold values. To less has than a value (=8192) corresponding to an image density of 50%. When the entire halftone dot area consists of 323 128x128 pixels; all the threshold values in the matrix off 555. Fig. 1(A) are to be used in generating one halftone dot is a consistent of the typical process of generating a halftone image successively reads out threshold values from the threshold matrix, compares the read-out threshold values with the

multi-tone-image-data-to-determine on/off-state-of pix-a-vix els, and generates a halftone-dot based on the result of sold the comparison. For the image density-of 50%, for example, halftone-dots having the rhombic area shown in Fig. 1(A) are recorded.

The conventional algorithms to the The conventional algorithms and the Theorem 1997 to the Conventional algorithms are the conventional algorithms and the Conventional algorithms are the con every does not always reflect the exact density bits expressed by multi-tone image data on the dot percent. The or the halftone dot area rate. When the entire halftone dot area consists of 6x6 pixels according to a specified screen ruling, for example, 6x6 threshold values are read out from the threshold matrix of Fig. 1(A) to be at compared, with multi-tone image data while other threshold values are skipped. Fig. 1(B) shows positions of threshold values read out from the matrix under such conditions, and Figs 1 (C) shows the read-out threshold values... When the value of multi-tone image data is 8192; the pixels which have threshold values less than 81925 are rexposed ator generate a shalftone idot. The same threshold values circled in Fig. 1(C) have values less 10% than 8192, and the pixels having these threshold values are recorded as shown by the solid circles in Fig. 1(B) to generate a halftone dot. The example of Fig. 1(B) includes (13) pixels of solid circles, which means the dot and percent of 13/36=0:36 (36%). Since the value of the multi-tone image data (=8192) corresponds to the density of 50%, the dot given in Fig. 1(B) does not faithfully to a reproduce the tone level expressed by the multi-tone image:data::Like this example: the Irrational Tangent Method may not accurately reproduce the dot percent corresponding to the tone level expressed by the multitone image data. Similar problem is also observed in the 1000 Rational/Tangent/Method) princeles de agets am celbulone de con-crad threst lid chairiges according to the offset,

SUMMARY: OF THE INVENTION to accord on a find graph of a condition of the same of the condition of the conditions are same.

An object of the present invention is thus to generate halftone dots which faithfully reproduce a tone level the specified:by/multi-tone (mage:data)=dirtue ent. assons! (0) def The present invention is directed to a method of comparing multi-tone image data with a threshold value """ to generate a halftone image signal representing any on/offistate of each of pixels arranged in lattices on an Abb image plane, and forming a halftone dot in response to the the halftone image signal in each halftone dot area which is repeatedly arranged to form an array of halftone dot areas on the image plane. The method comprises the step of: (a) correcting at least either of the multi-tone image data and the threshold value so that a halftone dot is formed in the each halftone dot area to have a desired halftone dot percent specified by the multi-tone image data? (Milios ripporti) voli enti prin si

The above method compares corrected multi-tone image data with a threshold value or alternatively multi-tone image data with a corrected threshold value, thereby forming a halftone dof having a desired dot period cent corresponding to the multi-tone image data in each halftone dot area. This results in generating halftone

្នុងនេះ ប៉ុន្តែប្រាស្ត្រ។ និងប្រហាតិដី ស្រែកស៊ីនី ស្រាក់ប្រាសិន

dots which a faithfully preproduce validesired at one elevel but specified by the multi-tone image data. It is a sea and provide the control of the control

Referably, the step (a) includes the steps of (b) determining an offset for the each flafftone dot area including a subject pixel to be processed, as a function of a resolution of the pixels as well as a screen ruling and a screen angle which define the arrayof halftone dot areas on the image plane, the offset representing a deviation of a predetermined reference point of the each halftone dot area from the pixel lattices; and (c) correct ing at least either of the multi-tone image data and the streshold value according to the offset of the second constant of the shold value according to the offset of the second constant of the second

Since the appropriate degree of correction depends, more on the offset of the halftone dot-area; the above steps and attain appropriate correction according to the offset has not its

In a preferred embodiment of the present invention is not the method further comprises the step of preparing a use plurality of correction book-upitables with respect to ask (8 plurality of combinations of the screen ruling, the screen of angle, the resolution of the pixels, and the offset, the repopularity of correction look-up tables being adaptable to need be used to perform the correcting at the step (c)). Furrent then, the step (c) includes the stepsof: selecting one of the plurality of correction look-up tables according to the step offset, and correcting one of the multi-tone-image data ones and the threshold value-based on the selected correction look-up tables.

In another embodiment, the step (a) further some open prises the step of preparing a plurality of corrected semi-threshold matrices with respect to a plurality of combenies nations of the screen ruling afterscreen angle, the respense lution of the pixels; and the offset; and wherein the step enotic includes the steps of selecting one of the plurality of size corrected threshold matrices according to the offset; and reading out a corrected threshold matrix thus selected.

The desired halftone dot percent corresponding to-multi-tone image data; losis given by: M(lo)/Mt, where deta M(lo) denotes the number of pixels to form the halftone costs dot in the each halftone dot area. The step (a) multi-tone image: of data to be greater than an M(lo)-th-lowest value amonghem Mt threshold values corresponding to Mt pixels existing permit in the each halftone dot area. If lacuis epemies con an 48

Alternatively, the desired halftone dot percent corresponding to multi-tone rimage data to is given by the M(lo)Mt, where M(lo) denotes the number of pixels to and form the halftone dottin the each halftone dottarea, and the denotes a total number of pixels in one halftone dot so area; and wherein the step (a) includes the step of correcting the lowest through an M(lo)-th lowest values among. Mt threshold values corresponding to Mt pixels existing in the each halftone dot area to be less than the multi-tone image data loggression.

The present invention is also directed to an apparatus for comparing multi-tone image data with a threshold value to generate a halftone image signal representing an on/off state of each of pixels arranged

in lattices on an image plane, and forming a halftone dother in response to the halftone image signal in each halftone dot area which is repeatedly arranged to formen DAS array of halftone dot areas on the image plane. The apparatus comprises: a threshold memory for storing the threshold value representing a shape of a halftone dot according to an simage adensity; and correction means for correcting at least either of the multi-tone of the image data and the threshold value so that a halftone of so its formed in the each halftone dot area to have a desired halftone dot percent specified by the multi-tone seed image data.

In a preferred embodiment of the present invention, the correction means includes effset calculating means for determining an offset for the each halftone dot area including a subject pixel to be processed, as a function of a resolution of the pixels as well as a screen ruling and a screen angle which define the array of halftone dot areas on the image plane, the offset representing a deviation of a predatermined reference point of the each halftone dot area from the pixel lattices; and correction executing means for correcting at least either of the multisquerimage data and the threshold value according to the offset age of a close y

Referably: the corrections executing means includes: look-up table preparation means for preparing a plurality of correction took-up tables with respect to a plurality of combinations of the screen ruling; the screen angle, their esolution to the pixels and the offset, the plurality of correction took-up tables being adaptable to be used to correct the multi-tone image data; selection means for selecting one of the plurality of correction look-up tables according to the affect calculated by the offset calculating means; and means for selection the plurality of correction the insulation multi-tenesimage data based on the correction look-up table selected by the selection means and a selected by the sel

The destred halftone dot-percent corresponding to his multi-tone image data florisitiven by M(Id)/Mt) where sold M(Id) denotes the number of pixels to form the halftone percent detinities activated to replace the number of pixels to form the halftone percent number of pixels in one halftone dot area. The look-up reduce table preparation means includes means for obtaining base corrected multi-tone image data to the dowedted multi-tone image data. In the dowedted multi-tone image data. In the dowedted multi-tone image data. In the being set to be greater than an M(Id) the lowest value among Mt threshold value corresponding to Mt pixels and existing in the each halftone dot area; and means for each registering relations between the multi-tone image data. In the corrected multi-tone image data to into these propurative of correction look-up tables or 253 85 (a. 36 to 16 (4)).

In another embediment; the Acorrection executing an embediment; the Acorrection executing an embediment; the Acorrection execution emeans for a preparing amplurality of confection flock-up tables with the respect to a plurality of combinations of the Screen rule of the screen angles the resolution of the pixels; and the offset, the plurality of correction took-up tables being adaptable to be used to correct the threshold value; and selection means for selecting order of the plurality of correct rection look-up tables according to the offset calculated

. "\$4

by the offset calculating means; and means for correct-fileing the threshold value-based on the correction look-up table selected by the selection means.

The desired halftone dot percent corresponding to a multi-tone image data to is given by M(lo)/Mt, where so M(lo) denotes the number of pixels to form the halftone dot in the each halftone dot area, and Mt denotes a total an umber of pixels in one halftone dot area. The look-up so table preparation means includes: means for determining corrected threshold values by setting the lowest and through an M(lo)-th lowest values among Mt threshold values corresponding to Mt pixels existing in the leach halftone dot area to be less than the multi-tone image data los and the corrected threshold was value into the plurality of correction look-up tables:

In another aspects of the present invention the apparatuse comprises: coffset : calculating emeans for this determining an offset for the each thatftone dot area and including a subject pixel to be processed; as a function 20 of a resolution of the pixels as well as a screen ruling (90) and a screen angle which define the array of halftone mendot areas on the image plane; the offset representing also o deviation of a predetermined reference point of the each 100 halftone dot area from the pixel lattices matrix preparate 125 tion means for preparing a plurality of corrected threshald as old matrices for a plurality of combinations of the screen files' ruling, the screen angle, the resolution of the pixels, and the offset, the plurality of corrected threshold matrices igna being stored in the threshold memory and adaptable to 38 be compared with the multi-tone image data-so that analo halftone dot is formed in the each halftone dot area to iouz have a desired halftone-dot-percent specified by aheliang multi-tone image data; selection means for selecting one of the plurality of corrected threshold matrices also according to the offset calculated by the offset calculateers ing means means for reading out a corrected threshold the value from the threshold memory selected by the selection tion means; and comparison means for comparing the යිමාම corrected threshold value read out from the selected corrected threshold matrix with the multi-tone image ball data, thereby generating the halftone image signal large eff.

The desired halftone dot percent corresponding to the multi-tone image data lonis given by M(lo)/Mt, where M(lo) denotes the number of pixels to form the halftone M(lo) denotes the number of pixels to form the halftone dot in the each halftone dot area, and Mt denotes a total number of pixels in one halftone dot area. The matrix preparation means comprises means for correcting the lowest through an M(lo)-th lowest values among Mt threshold values corresponding to Mt pixels existing in so the each halftone dot area to be less than the multi-tone and image data lo, to thereby obtain corrected threshold values to be stored in the plurality of corrected threshold matrices.

These and other objects, features, aspects, and 555 advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

as les vilenes fors.

Figs. 1(A) through 1(C) show a process of generating dots by the Irrational Tangent Method; Figs. 2(A) through 2(C) show a fundamental idea of

correcting image data in the present invention;

Fig. 3 shows an exemplified relationship between halftone dot areas and pixel positions in an image plane, hardsmall and works works

Fig. 4 shows the relationship between halftone dot areas and pixel positions with the varied screen angle 6:

Fig. 5 shows the relationship between halftone dot areas and pixel positions with the varied screen ruling (LPI);

Fig. 6 shows the relationship between halftone dot areas and pixel positions with the varied resolution (DPI) of the output device.

Fig. 7 shows coordinates assignable to a reference point in one halftone dot area.

Fig. 8 shows the positions of threshold values referred to at the division coordinates (i,j); (i) and a flowchart showing a routine of preparing -

Fig. 9 is a flowchart showing a routine of preparing screen gradation tables of the land and the land of the land

Figs. 10 his at flowchart showing details of the processing executed at step S5 in the flowchart of Figs 9 pages 6. Or also set awards (\$10.00) years to process the second of the process of the process

Fig. 11 is a block diagram illustrating the structure of a halftone image recording system for generating halftone images embodying the present invention;
Fig. 12 shows a primary scanning direction V and a secondary scanning direction U on the photosensitive film and on about 20 many 26 many 2

Fig.-13 is a flowchart showing an operation of the halftone image recording system of the embodi-

Fig. 14 is a block diagram illustrating functions of the screening process unit 116;

Fig. 15 shows a correction curve prepared when the input density value to and the corrected density value to are set as data of different bit numbers;

Figs. 17(A) and 17(B) show the halftone dot area coordinates (Xi,Yi) and the SPM address (Xd, Vd) with respect to the screen coordinates (X,Y);

Fig. 18 shows an update of the halftone dot area coordinates (Xi,Yi) with an update of the beam spot sposition;

Fig. 19 shows the actual procedure executed at step S34 for determining the division coordinates

Fig. 20 is a block diagram illustrating another structure of the screening process unit and screen pattern memory;

Fig. 21 is a block diagram illustrating still another structure of the screening process unit and screen pattern memory; and

Fig. 22 shows a correction curve including a non-198 linear relationship between the input density value and the number of pixels to be exposed; (A) = 31.15

DESCRIPTION OF THE PREFERRED EMBODIMENT

ாட் நிக்கட் நாட்டு முத்தார் ஓரங்கள் A. Fundamental Idea of Correcting Image Data த நடத

Figs. 2(A) through 2(C) show a fundamental idea of correcting image data in the present invention. The left part of Fig. 2(A) is a graph with input image data (input density value) to as abscissa and the number of pixels to be exposed as ordinate. In the description hereof, the term pixel represents a smallest recording unit on an output device used for recording halftone images. Singe the output device applied herein typically utilizes a light beam for recording halftone images, each pixel on the output device may hereinafter be referred to as a beam spot on the device may hereinafter be referred to as a beam spot on the device may hereinafter be referred to as a beam spot on the device may hereinafter be referred to as a beam spot on the device may hereinafter be referred to as a beam spot on the device may hereinafter be referred to as a beam spot on the device may hereinafter be referred to as a beam spot on the device may hereinafter be referred to as a beam spot on the device may hereinafter be referred to as a beam spot on the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred to as a beam spot of the device may hereinafter be referred t

In order to reproduce the density of an image faithfully, the number of pixels to be exposed should be pro- 25 portional to the input density value to representing the image density. Fig. 2(B) shows the pixels to be exposed: when an input density value to (=8192) is used without any correction; this is identical with the drawing of Fig. 1(B). One method of the present invention corrects the 30 input density value to as shown in Fig. 2(A) to adjust the number of pixels to be exposed in For the input density value to of 8192 which corresponds to the image denvi sity of 50%, for example, the multitone image data is corrected to realize 50 dot percent in each halftone dot- 35 area. When the multi-tone image data is corrected to become a corrected density value to of 8900, for example ple, the number of pixels with threshold values less than: 8900 (see Fig. 1(C)) will be equal to 18 as shown in Fig. 2(C). The number of pixels to be exposed by the corn 40 rected density value ic is thus, equal to 18, which exactly reproduce the image density of 50% wolf a 2000 pm

The positions of threshold values referred to in a threshold matrix are varied with a screen angle θ and a: screen ruling Rh (line per inch (LPI)) of a halftone image - 45 of concern and a resolution Rd (dot per inch (DRI)) of an output device applied, such as a record scanner. Fig. 3. shows an example of halftone dot areas applicable to an image plane. In the drawing of Fig. 3, intersections of smaller square lattices represent positions of beam, 50 spots in the output device, and larger square lattices: inclined by the angle of 0 specify boundaries of halftone dot areas. One threshold matrix is applied to each halftone dot area specified by a larger square lattice, and threshold values corresponding to the positions of intersections of the smaller square lattices are read out from the threshold matrix, and compared with multi-tone image data. In the description hereafter, the square lattices for defining positions of beam spots are referred to

as beam lattices' and those for specifying boundaries of halftone dot areas ase'screen-tattices. The pitch of each beam lattices is equal to the reciprocal of the resolutions of the putput device, whereas the pitch of screenatices is equal to the exerciprocal of the screenatices is equal to the exerciprocal of the screen tuling Bholm, and the description, and year, and condinate system is used tool of express the specifinates of beam-lattices, (hereinaften too referred to as beam coordinate system), and an XY the coordinate system to express the coordinates of threshold of values in the threshold matrix (hereinaften referred to as screen coordinate system).

Theefour halftone dote areas illustrated in Fig. 3 100 include beam spots at different positions. The upper-left that vertex of each halftone (dot/area) denotes la freferencé and points and a deviation of the reference point in each halftone dot area from the closest upper-left point of the corresponding sheam slattices (shown by broken-line) arrows in the drawing) represents an offset of the halftone dotrarea or 'dotroffset'. The four halftone dot areas said shown in Fig. 3 respectively have different dot offsets OF1 through: OF4.:Any two halftone dot areas having and the street of th identical, dot offsets include beam spots, at identical positions - Anyetwo halftone idotrareas having different: dot offsetseon the contrary, include beam spots at different positions. The characteristics of the correction curve see: as shown in Fig. 2(A) thus depends on the offset of the tr'd granices for a duranty of combinations cases tobegotted

Figs 4-shows ranother, example, where the screen plant angle 9-is different from that of Fig. 13. Ascan be clearly as a seen dromating companison shetween Figs. 13 rand 14) as need change in screen angle (it varies if be positions of beam of spots included time exists that fit one dot area; chart is, the wind positions of threshold values referred to had be used as exist.

Fig. 5 shows still another example where the screen is the ruling. Althis different, from that ob Fig. 3.13 her smaller and screen ruling. Blass in the example of Fig. 5 denlarges and accordingly lincrease either on each halftone; dot area and accordingly lincrease either on number of beam; spots included in reach halftone dot down area, and paragraph nor an amen nor increase but a conservation and of the shows another example where the resolution and of the putput device as different from that of Fig. 3.5 mor. The smaller resolution and of the output device as time example of Fig. 6 results on a rougher pitch of the among the report thereby, decreasing the number of beam spots that included in each halftone dot area.

The positions of threshold values referred torinseacher too halftone dot area are thus varied with the offset of the from halftone dot area, the sorgen angle of the screen ruling now a Rh, and the resolution Rd of the output device. These est will characteristic values observing the characteristic values observe the correction curve as shown in Fige 2(A). another dose est the correction curve as shown in Fige 2(A), another dose est the correction of the corr

Before describing the method of determining a cord? rection curve, a possible value range for the offset of the mode halftone dot area is explained first. As described previously along with Fig. 3, the offset of each halftone dot less area determines the positions of threshold values are

referred to in the halftone dot area. Restricting the possible value range for the offset of the halftone dot area as to a number of predetermined values will result in restriction of the number of required correction curves. Fig. 7 shows local coordinates assignable to a reference 5: point Pref in a certain halftone dot area (the reference point is the upper-left point of the certain halftone dot area in this embodiment). Lattice points expressed by: solid circles in the drawing of Fig. 7 represent the positions of beam spots (points of exposure) on the output -10 device, wherein the pitch of beam spots is equal to 1/Rd. In this embodiment, the pitch of beam spots (hereinafter may be referred to as pixel pitch) is divided and into N equal parts, and intersections of NxN lattices are set as permissible positions for the reference point Prefigure within the small area defined by the four beam spots. In good the example of Fig. 7, N is equal to 6, and therefore 36 positions expressed by coordinates (i,j), where i=0 to 5, 0, a and j=0 to 5, are set as the candidates of the reference point Pref. The dot offset OF is given as a vector from 20 the position of the closest beam spot existing on the dead upper-left of the subject-halftone dot, area to the refers 159 ence point Rref of the subject halftone dot area. The ence NxN positions assignable to the reference point Prefute accordingly give different values to the dot offset OF-02 ,1725

In the description athe coordinates (i.j.) representing 4 10 the candidates of the reference point Pref are referred to naxe as division in coordinates to (i,j) the Theo idot is offset a OFs base expressed by the unite of distance (inch) is requalities to (i/Rd,i/Rd)...Incidentally...values other than the division50 coordinates (i,j) or the distance (i/Rd,j/Rd) of the dot off-round set OF may also be used as the dot offset index indicate units ted in the screening procesulary test of the NxN dot offset values processing processing

Figs#8irshows other positions rofe-threshold values referred to. The positions of threshold values referred to 35 in each halftone dot area: (that is, the positions of beam used spots) are determined by the division coordinates (i,j) of size the dot offset QF, the screen roling Rh, the screen angle 323 θ, and the output resolution and Since there are elixible is sets of possible division coordinates (i,j) for the dot off-suito: set OF; NxN:correction#curves#are_required_for# each? combination of the screen ruling Rh, the screen angle 6,2 963 and the output resolution Rd:noo graneb is selfulonife? If this

In this embodiment, flook-up tables are used for the realizing the correction curves as:shown in Fig. 2(A).3in 145 the description hereafter, the look-up table may be referred to as !correction:look-up!table!or !screen:gradation table'...A memory for storing a threshold matrix cor-1/33 responding to one halftone dot area is referred to as a second 'screen pattern memorybor 'SPM'; co to said to anoth in iso

Fig. 9 is a flowchart showing a routine of preparing screen gradation tables. At step-Sighthe values of the and division coordinates (i,j) are initialized to (0,0). The program then goes to step S2 to determine the distance (i/Rd,i/Rd) of the dot offset OF at the division coordi- 55 nates (i;j)...All look-up values included in the halftone dot to the area specified by the distance of the dot offset OF (that and area is, threshold values at the positions expressed by the black circles in Fig. 8) are read out from a screen pattern memory at step S3. Addresses of the look-up val- 3/5 ues are determined from the distance (i/Rd,i/Rd)(of the section) dot offset-OF; the screen ruling Rh, and the screen with angle θ.eno of toeure.

The program then proceeds to step S4, at which all the look-up values read at step S3 are sorted in the ascending-order. When the look-up values include 36% of threshold values shown in Fig. 1(C), for example, the 36 200 threshold values are rearranged in the order of 20, 40, 11 Vi-50, 60 and 16382 120

At step S5, a corrected density value is determined for each input density value. Fig. 10 is a flowchart show-14.59 ing details of the processing executed at step S5 in the flowchart of Fig. 9.4 step Stal, the input density value. is initialized to zero. The program then goes to step \$12; 10 to at which a required number of pixels M to be exposed: 500 for the faithful reproduction of the input density value is calculated according to the following equation (1):

not always he also to aren't have the or or always on the where Mt denotes a total number of pixels in the half-4 --51 tone dot area, lo an input density value, and lmax a density range. The density range Imax is synonymous with the maximum value of the input density value lo. When the the input density value to is expressed as 8-bit/data. for the example, Imax=255. The total number of pixels Mt is equal to the total number of look-up values read at step! S3 in the flowchart of Fig. 9. The above equation (1) determines the required number of pixels M to be exposed by multiplying the total number of pixels in the halftone dot area by the density percentages to consider a second

At step \$13 among all the look-up values sorted at: ** step \$4/in the flowchart of Fig. 9/ an (M+1) th look-up value is adopted as a corrected density value lo. This is ascribed to the following reasons. In this embodiment, on/off of each beam spot is determined according to the inequalities (2a) and (2b) given below: new policy 등 기술 교육 설명 350 ಗರಿಭ ಸುಭಾರ ೧೨ ರ ಸ. ೧%,

Elay enem, soni-fix.

tage control him arrest to to give his believe the green

where TD denotes a threshold value, and Ic denotes a corrected density value. A separate print the

Thus, selecting the (M+1)-th look-up value as the corrected density value ic will cause M pieces of beam spots to be exposed in this halftone dot area. This gives a dot percent of (M/Mt), which faithfully expresses the tone level of the input density value lo. - A street level is to

The program then goes to step \$14, at which the corrected density value ic is written into the correction look-up table while using the input density value to as a car an address. This completes the process for one input entices of a little of the second each density value lo.

After incrementing the input density value to by one at step S15, the program returns to step S12 to repeat the process of steps S12 through S14 until the input density value to reaches the maximum Imax at step

S16. Executing the process of steps S32ahrough: S45 16.1 for all the input density values to incarrange of 0-to dmax 16.1 gives; one screen gradation table representing the characteristics of a correction curve with respect to one dot gooffset (i,j), the second second

When the input density value to reaches the maximum, Imax at step \$16, the program-goes to steps \$6 point through \$9 in the flowchart of Figs.9 to increment if or it is by one until both j and i reach the value. No The process and of steps \$2 through \$5 are executed for all the division and coordinates (i.j.), so that NxN sets of screen gradation tables were prepared, respectively for NxN dot offsets and (i/Rdij/Rd) (wherein, 0si,j<N). A table number where an assigned to each screen gradation table for the purpose wolf of identification. The table number Nt. is given, for example to the purpose with the purpose wolf of identification. The table number Nt. is given, for example a discrete play the gradation of the purpose with the purpose wolf of identification. The table number Nt. is given, the example a discrete play the gradation of the purpose wolf play the gradation of the purpose with the purpose with the purpose of the purpose of

In this case, table numbers in a range of 0 to (NxN- 20 1) are assigned to the NxN sets of screen gradation tables. The distalking its rediction space of screen its sealow of the set of t

The process of Figs. 9; and HO; with provide a NxNe not pieces of screen gradation; tables for each combination; the of the screen gradation; tables for each combination; the of the screen gradation; the screen angle of and the outhiness put resolution. Rds to be sections at a sentent gradual element of element of the screen angle of the screen

Fig. 11 is a block diagram illustrating the structure erap of a halftone image recording system applied as an outcome put device for generating-halftone images embodying that the present invention. The halftone image recording system includes a screening processor; 100; an; output gets interface unit-200, and an output process unit 300. The ulas screening processor 100 includes in GPU tracentral took processing unit) 110, a RAM (random access memory) place 120, an SPM (screen pattern memory), 130, a hard diskecers 140, and an output port 150. Multi-tone image data, which are subjected to the screening process, are stored in the hard disk 140. In the process of generating halftone images, a beam position pulse signal Sb representing an update timing of the beam spot in the output process unit 300 is transmitted from the output process tar v. unit 300 to the screening processor 100. The screening 45 processor 100 executes the screening process synchronously with the beam position pulse signal Sb. The term are the 'screening' or 'screening process' in the description represents a process of generating a binary halftone image signal from multi-tone image data and and are the said as 50

The GPU, 110 executes software programs stored in the RAM 120 to realize the functions of a look-up table preparation unit; 112, an input/output control unit to 114, and a screening process junit; 1,16. The look-up a retable preparation unit 112 executes the process of preparing screen gradation tables according to the routine of Figs., 9 and 10. The screening process unit; 1,16 determines on/of of each beam spot according to the inequal-

DOMESTIC OF SELECTION OF THE SERVICE OF THE

ities (2a) and (2b) given above to generate a binary the halftone image signal RS:

The halftone image signal RS generated in the screening processor 100 is supplied to the output process unit 300 via the output port 150 of the screening processor 100 and the output interface unit 200. The output process unit 300 records a halftone image on a photosensitive film in response to the halftone image signal RS. Fig. 12 shows a primary scanning direction V and a secondary scanning direction U on the photosensitive film. The secondary scanning direction U and the primary scanning direction V and the primary scanning direction V are identical with the coordinates U and V in the beam coordinate system (Fig. 3).

Fig. 43 is a flowchart showing an operation of the screening processor 100. When the program enters the routine, initialization of the screening processor 100 is executed to set the screen ruling Rh and the screen angle 6 of a resulting halftone image and the resolution " Rd of the output device at step \$20. The program then The goes to step S21; at which screen gradation tables are "" prepared for the combination of preset values (Rh, 0, Rd) according to the procedure of Figs. 9 and 10. The screen gradation tables thus prepared are stored in the RAM 120 In accordance with one preferable application, screen gradation tables are prepared in advance for typical combinations of preset values (Rh, 16; Rd) (for res examples{Rhe175:LiP;9±0,15;45;75; Rd=4;090(DRI})20元 and stored in the hard disk 140. Screen gradation tables : *** corresponding to the input combination of preset values and the (Rh, 0) Rd) are read from the hard disk #40 and written Unit into the RAWet20 for use in the screening process. This has structure allows the processing of step \$24 to be omit? 2,198 ted in the screening processles table to MXM and to end gat

Abstep \$22; anulti-fone image data/corresponding? To one beam spot (thattis/ran-input density/walde to) is more input interthe annultoutput control unit all the tonbel subbless proceed to binary rooding. The program them goes to step store \$23, at which the screening process units? 16 generates at 4 ft a halftone image signal rRS based on the input density one of value for one of notify; is established to color or endescopie as a

Figs.44 is asblock diagram/illustrating functions of 1986 the screening procession to unit 116 includes a density correcting anit 362 partiable 1986 number selecting unit 364, an-SPM address calculating 1997 unit 166, and an on/off determining unit 168 modernt graphs and an on-off determining unit 168 modernt graphs.

The units 162s:164; and 166 correspond to the corespond to the corespond to the corespond to the coresponds for the coresponds to the configuration offset calculating means; for determining am offset to recent the halftone dot area of concern, and the table number send selecting unit 164 corresponds to the selection means if for selecting a screen gradation table according to the coffset on the coffset of the corresponds to the selection means if

The SPM address calculating unit 166 calculates an address (Xd, Yd); of the screen pattern memory (130 for the beam spot) that is under the screening process of the beam spot) in response to the beam position pulse signal Sb transmit at ted from the output process unit 300; and supplies the Art St

address (Xd,Yd) to the screen pattern memory: 130. A threshold value (look-up value) TD corresponding to the address (Xd,Yd) isgread out from the screen patternes. memory 130. In the example of Fig. 14 look-up values. TD are 14 bit digital data. The SPM address calculating 15 unit 166 further calculates division coordinates (i,j), rep.: 1 resenting an offset of the halftone dot area including thesens subject beam spot, and supplies the division coordinates (i,j) to the table number selecting unit 164. Details of the processing executed in the SPM address calculating unit 166 will be described later. V. 1, 14 45

The table number selecting unit 164 determines the table number. Nt corresponding to the division coordinately. nates (i,j) according to the equation (3) given above..... The density correcting unit 162 selects one screen gradulate dation table according to the table number Nt given by it of the table number selecting unit 164, and registers the well input density value to at the address of the selected party table so as to read the corresponding corrected density had value lc. In the example of Fig. 14, the input density. 20 value logis 8-bit data, while the corrected density value same Ic is 14-bit data as is the threshold values TD-read out lines. from the screen pattern memory, 130. The input density some value to and the corrected density value to may have different, bit ; numbers "as; seen) in this example :: Fig. ::151/252 shows:a:correction:curve prepared:when the input/den-eulev sity value to and the corrected density value to have difensiti ferent bit numbers. The correction curve of Fig. 45 is 18145 substantially-identical with that of Fig. 2(A): but with a different scale or abscissa in the left-hand graph repres gass senting the relationship between the input density value hado To and the number of pixels to be exposed) such a read be if

The corrected density value los obtained in the idensity value los obtained in the idensity value. sity correcting unit 462 is given to the on/off determining an ab unit 168; which compares the corrected density value to elast with the threshold value TD cread tout from the screen enter pattern memony 130 and generates a binary halftone sulav image signal RS according to the inequalities (2a) and with (2b) given above. The halftone image signal aRS athus fueer generated is supplied to the output process unit 300 via 40 the output porto150 and the output interface unit 200 peles (Fig. 15k). A halftone image is recorded on a photosensi-19th to tive film-in-response to the halftone image signal/RS. RETE TOO

After the halftone images signal RS for one beams will spot is generated at step S23 in/the flowchart of Fig. 43) 145.1 the program goes to step \$24; at which it is determined state whether the processing is a completed for the whole of no range of the primary scanning direction V (Fig. 12). When not completed, the program returns to step \$22%. 3 to execute the process of steps S22 and S23 for a next 50 beam spot adjoining in the primary scanning direction V.5 When the processing is completed for the whole range of the of the primary scanning direction V, on the contrary, the contrary, program process to step S25 to execute the processing to the step of the processing to the processing for a next primary-scanning line. At step \$26, it is determined whether the processing is completed for the whole range of the secondary scanning direction U. When not completed, the program returns to step S22 167 when the position of exposure is varied by a pitch ΔV of to repeat, the process of steps #\$23 through \$24 \$ 1987

Repeating the process of steps S22 through S26 implements the generation of halftone image signals RS for all the range of the image, and records a resulting half- 5th tone image on a photosensitive film.

a In this embodiment, a plurality of screen gradation tables are prepared according to: the division coordinates (i,j) of the dot offset OF, the screen ruling Rh, and the screen angle θ of a resulting halftone image; and the resolution. Rdbof the output device. The input density value to is corrected according to one of the plurality of screen gradation tables thus prepared. The corrected density value ic is compared with the threshold value TD read out from the screen pattern memory 130. A halftone image signal RS is then generated on the basis of the comparison to faithfully reproduce the tone level expressed by the input density value to. The screen gradation tables can be prepared prior to generating a halftone image signal RS from the multi-tone image data (input density value to) as shown in Fig. 13? Thus this embodiment generates a halftone age which faithfully reproduces the tone level expressed by the input density value to without increasing the process time for generating the halftone image signal RS from the input density value to a seguin, an armor some notice of girlian see FE TEST PROBABLE AND ADMINISTRATION OF THE EQUADORY SET THE

D. Details of the Process of Generating a Halftone Image Signal for Each Beam Spot ento gradue on the land ento yri chanistopo i esti de aleton bhe unio i li i ad a anib

Fig. 16 is a flowchart showing details of the processing executed at step \$23 in the flowchart of Fig. 13. The process of step S23 shown in Fig. 16 is executed every time when one pulse of the beam position pulse signal Sb is transmitted from the output process unit 300 (Fig. 41) to the SPM address calculating unit 166 shown in Fig. 14. วจะ ยัวประโชล ของเน้าของสถาย (Xi, Yi)

At step S31, the screening process unit 116 updates screen coordinates (X;Y) in the primary scan ning direction V and determines an SPM address (Xd, Yd) and halftone dot area coordinates (Xi, Yi). Fig. 17(A) shows the halftone dot area coordinates (Xi,Yi), whereas Fig. 17(B) shows the SPM address (Xd,Yd). The halftone dot area coordinates (Xi,Yi) shown in Fig. 17(A) represent the position of each halftone dot area. The halftone dot area coordinates (Xi, Yi) consist of the integral parts of the screen coordinates (X,Y). Fig. 17(B) is an enlarged view illustrating a halftone dot area defined by the halftone dot area coordinates (Xi, Yi)=(1,2). The SPM address (Xd, Yd) shown in Fig. 17(B) represents the position within one halftone dot area (SPM area). The SPM address (Xd,Yd) consist of 6113 the decimal parts of the screen coordinates (X,Y).

The output process unit 300 records a halftone image by exposing a recording medium, such as a photosensitive film to a light beam running in the primary scanning direction V. The expression updating screen coordinates (X,Y) in the primary scanning direction V implies determination of the screen coordinates (X,Y) beam spots in the primary scanning direction V.

55

1243

Conversion of the beam-spot coordinates (UtV) tto 18.5 the equations (4a) and (4b) given below: eth to eight in

. Literational e no expension നുവും X = U t cosθ t.W t sinθer, കമേനം (4a) വ 5 that is are prepared in the interest and --Y = U • sinθ; + V • cosθ เกอบ ค่าก b(4b)) เลเลา 6.3(E. . 55.17.5) regerda.

By substituting U=m · \(\Delta U \) and \(V = n * \(\Delta V \); the equation is tions (4a) and 4(b) are rewritten as: a pathern a seaf state 0.1 gest 👵 1 soreen dictroling $\varphi_{i} \circ \varphi_{i} \times X = m \cdot \Delta U \cdot \cos \theta \cdot m \cdot \Delta V_{i} \cdot \sin \theta \in \mathcal{E} \cup (5a)$, then six the line is emitted the pass of a title in it ains, Yr= m • ΔU sinθ + n• ΔV∂ cosθne egu(5b) ruftis. tex forms on to take the remodern and the recording wherein m and n are integers, and AU and AV representations the pitch of beam spets in the secondary scanning and direction and the primary scanning direction (Fig. 417) are senso

Since the secondary scanning-coordinate Uthas abort fixed value on the entirety of one scanning line in the price 20 mary scanning direction. With sinteger m in the equationer tions (5a) and (5b) is constant/on each scanning lines/ 1992 Updating the screen coordinates (X-Y) in the primary at see scanning direction V only varies the integer n in the sectionab ond term of the right-hand side of the equations (5a) 25 and (5b) by one. Progress of the beam spot by one insc 1 the primary scanning direction Videcreases the X cooregant dinate by $\Delta V \cdot \sin \theta$ and increases the Y coordinate by

At step S31 of Fig. 16, screen coordinates (X; Y) areso 301 calculated according to the equations (5a) and (5b) T.81 given above, and the decimal parts of the screen coor-betto dinates (X,Y) are used as the SPM address (Xd;Yd) salid while the integral parts thereof are adopted as the half-8 film tone dot area coordinates (Xi,Yi). 188 shown in Fig. 14

The updating process of the secondary scanning coordinate Usatistep (\$25 in the flowchart, of Figs 13) state increments the integer main the first term of the right. pan hand side of the above equations (5a) and (5b) by one (150)

At step \$32 in the flowchart of Fig. 16, a threshold: 40 value TD at the updated SPM address (Xd; Yd) is read and out from the screen pattern memory 130 (Figo 14) north the first

The program then proceeds to step \$33, at which it 🛦 🎀 is determined whether the halftone dot area coordinates and (Xi, Yi) are revised by the calculation of step S31. Fig. 18 45: shows revision of the halftone dot area coordinates -(Xi, Yi) caused by an update of the beam spot position. The The halftone dot area coordinates (Xi,Yi) are revised when the beam spot position is shifted from one halftone dot area to an adjoining halftone dot area. In the example of Fig. 18, the halftone dot area coordinates = + (Xi, Yi) are revised from (1,2) to (0,2). Since different correction, curves are applied to different halftone dot. areas, the table number (i.j) is recalculated for the new halftone dot area including the subject beam, spot at ... 55, step \$34. The Soundary years a setting of Your effort

Fig. 19 shows the actual procedure executed at step S34 for determining the division coordinates (i,j). The halftone dot area coordinates (Xi,Yi) are identical with the screen coordinates (X,Y) of the reference point have (the upper-left point) Pref of the halftone dot area according to their definitions. At step S34, the halftone 1202 dot area coordinates (XI, Yi) are converted to coordinates in the U-V coordinate system, that is, coordinates (Uref, Vref) of the reference point Pref, according to the equations (6a) and (6b) given below: 1112 teas one promotes

Wref XI cose + Yi sine at off (6a) of the Brofisson Liexeouted in the BPM audining the Vref = -Xi •'ŝínθ'∓ Yi •'čosθ ਹਾਂ ਸ਼ਾਮਾ ਕਰ (6b) ਪ੍ਰਿਸ਼ਾਂ ਮ The factor aumoerise culturing unit 164 detection ses the

wherein :Urefrand Wreff are avalues including decimal **** parts. The integral parts of the coordinates (Uref. Vref) represent the coordinates of the upper-left pixel closest to the reference point Pref, whereas the desimal parts and thereof represent the offset OF of the halftone dot area (Fig. d.9) eThe idecimal parts of the coordinates (Uref, black Vref) are then substituted as the division coordinates (iii) into the equation (3). This process determines the analysis table number. Nta The number of the lower bits representing the decimal parts of the coordinates (Uref, Vref) (4.29) may besset to besaff integers atisfying the equation and N=2^m, where N denotes a number of divisions of the offset incone scanning direction (Figs 7) This allows the value of the lower bits representing the decimal parts of work the coordinates (Uref, Vref) to be directly used as the Vicinia division coordinates (fij) and correction of (ii) eathfuloco registrib

After the determination of the table number Nt at 1998 step S34: the program proceeds to step \$35 in the flow still a chart of Eig.vif6; at which a screen gradation table special as ified by the table number: Nt is selected: (Figs: 14), (and in the the corrected density valued corresponding to the input density value loss read outstrom the screen gradation with table thus selected. At step \$36, the corrected density in the value le is compared with the look-up value or threshold? value gread sout, from the screen pattern memory 130 1818 and generates:allhalftone image:signal-BS from the game result;of:the comparisonemi enotitori erili levode neuro (23) or In the process of Fig. 16; a screen gradation table is 404. selected for each halftone dot area lincluding the pixel 6 55 under processing according to the offset of the halftone (2015) dot area, and corrects the input density value based on Fig. 6. the selected screen gradation table. This gives the halftone image signals RS, which: faithfully reproduces the follow tone level expressed by the input density value; based of 900 on the offset of each halftone dot area is a sound entities to range of the primary soluning presents in (Fig. 12)

to premit a the properts of steps 1922 and 323 to 1 had Fig. 20 is a block diagram illustrating another structure of ture of the screening process unit and screen pattern 🖮 🛝 memory; The structure of Fig. 20 includes an SPM cor- and icrecting unit 170 in place of the density correcting unit 100% 162 of Fig. 14: The SPM correcting unit (170) corrects: 188 each threshold value TD read out from the screen pat- 351 TO tern memory 130 to generate a corrected threshold for we value TDc. The on/off determining unit d68 compares at 5 the corrected threshold values TDc with the input den-

Ser. E. Ottrer/Embodiments et, manyons enviloneteligmod fon her W

EG.

50,0

sity value lo and generates a halftone image signal RS based on the result of the comparison. Like the density correcting unit 162 shown in Fig. 14, the SPM correcting unit 170 includes NxN correction tables corresponding to the respective division coordinates (i.j) of dot offsets. One correction table is selected according to the table number Nt determined by the table number selecting unit 164. Each correction table included in the SPM correcting unit 170 is a look-up table, from which an 8-bit corrected threshold value TDc is read out while using each 14-bit threshold value TD read out from the screen pattern memory 130 as an address. The contents of the correction tables are predetermined to attain the faithful reproduction of the tone level expressed by the input density value lo. In the structure of Fig. 20, the look-up table preparation unit 112 calculates the contents of each correction table included in the SPM correcting unit 170 and writes the calculated contents into the RAM 120 at step S21 in the flowchart of Fig. 13.

The units 164, 166, and 170 correspond to the correction means for correcting threshold values and

Correction of threshold values TD, which is read out: from the screen pattern memory 130 according to the dot offset as in the case of Fig. 20, gives a substantially identical result to that attained by the structure of core recting the input density value low (Figs 14) as not enoticed

Fig. 21 is a block diagram illustrating still another structure of the screening process unit and screen pattern memory. The structure of Fig. 21 includes an SRM number selecting unit-180 in place of the table number 30 selecting-unit-164 and an SPM unit-190 in place of the screen pattern memory 130 and the SPM correcting: unit 170 of Fig. 20. The SPM unit 190 includes NxN screen pattern memories corresponding to NxN dot off A sets. Each screen pattern memory included in the SPMv unit 190 is a RAM in which corrected threshold values TDc corresponding to each dot offset are written at the respective look-up positions. Arbitrary values can be assigned to the threshold values which are not to be looked up. The corrected threshold values TDc read out: from the SPM unit; 190 are identical with those output. from the SPM correcting unit 170 in the embodiment shown in Fig. 20. In the structure of Fig. 21, the look-up table preparation unit 112 calculates the contents of each screen pattern memory included in the SPM unit 190 and writes the calculated contents into the RAM. 120 at step S21 in the flowchart of Fig. 13. The look-uptable preparation unit #12 functions; as the threshold matrix preparation means for preparing a plurality of threshold matrices.

The SPM number selecting unit 180 determines an SPM number N_{SPM} according to the division coordinates (i,j); given; by the SPM-address; calculating unit 166. The SPM number N_{SPM} is equivalent to the table: number. Nt. in the embodiment of Fig. 20 and used toidentify a screen pattern memory corresponding to each: dot offset. A screen pattern memory is selected from the plurality of screen pattern memories included in the SPM unit 190 according to the division coordinates (i,j).

and the corrected threshold values TDc is read out from the the selected screen pattern memory. The corrected was threshold values TDc is compared with the input density value lo to generate a halftone image signal RS.

The structure of Fig. 21 uses a plurality of screen pattern memories, each of which stores corrected threshold values corresponding to each dot offset, and accordingly: does not require any correction look-up tables as used in the embodiments of Figs. 14 and 20: The structure of Fig. 14 or Fig. 21; on the other hand; does not require NxN screen pattern memories corresponding to the respective dot offsets, but uses only one screen pattern memory. 31 331-01

The above embodiments are only illustrative and not restrictive in any sense. There may be many changes, modifications, and alterations without departing from the scope or spirit of essential characteristics of the invention: note a subtrail removed tup an Some examples of modification are given below.

is allow the inclination made dead. The correction curve shown in Fig. 2(A) or Fig. 15 shows a linear relationship between the input density value to and the number of pixels Mitobe exposed. The principle of the present invention is also happlicable to a "non-linear" relationship expressed by a curve M=f(lo) as shown in Fig. 22. When the correction curve includes a non-linear relationship as shown in Fig. 22, the process of step S122 in the flowchart of Fig. 10 determines the number of pixels M to be exposed corresponding to the input density value to by the function M=f(lo). In accordance with a concrete procedure: the corrected density value Ic is set to be greater than an M-th: lowest:/value-among/Mt pieces-of-threshold values, which correspond to Mt pixels existing in a halftone dot area. Alternatively, the correction of threshold values is implemented by correcting threshold values up to an M-th lowest value among Mt threshold values, which correspond to Mt pixels existing in a halftone dot area; to be less than the input density value lo: This method would generate: a halftone dot having a desired dot percent of M/Mt corresponding to the input density value in each halftone dot area/dandens, gold asidar qualicel risk

(2) The principle of the present invention is applicable to the Rational Tangent Method as well as the Irrational Tangent Method described above. When applied to the Rational Tangent Method Bat least either of an input density value and a threshold value is corrected to generate a halftone dot having a desired dot percent corresponding to the input density value in each halftone dot area, thereby reproducing a desired tone corresponding to the input density value. It show an appropriate of some "W 778 1 514

Although the present invention has been described and illustrated in detail; it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope

personable persons

45

of the present invention being limited only/by the terms unit of the appended claims.

÷...

YOUR ESTABLIBER OF CLOSULE

Claims

THE STRUCTURE OF PR. 21 1 ; 3 LINE 1. A method of comparing multi-tone image data with 15%. a threshold value to generate a halftone image signal representing an on/off state of each of pixels. arranged in lattices on an image plane, and forming a halftone dot in response to said hälftone image 10 signal in each halftone dot area which is repeatedly arranged to:formian array of halftone dot areas on income said image plane, said method comprising the step 8.5% THE DOTTE OF SUR BITT ofits races of which r gue of exilonium 175 ya 5. Þ (a) correcting at least either of the multi-tone simage data and the threshold:value so that a polihalftone dot is formed in said each halftone dot

area to have gasdesired halftone dot percentmiss

THE PROPERTY OF THE SER IN FIG. 2. A method in accordance with claim-1, wherein said step (a) lincludes the steps of: and it author distreti a premiero mesencied in economic entitie cui (b) determining an offset for said each halftone 69 dof area/including :a\subject pixel\ to: beaproc-TEE essed, as a function of a resolution of the pixels estas well, as a screen ruling and a screen angle: ed which define the array of halftone dot areas on a pthenimageoplaneposaid-offset representinguadeviation of a predetermined reference point of said each halftone dot area from the pixel latmy tices; and to so of fee at his every vitaries better No (c) correcting at least either of the multi-tone simage data; and the threshold value according. 35 halfone dot area. Attornails etc. ptestio biasable if threshold values in implemented by correcting

specified by the multi-tone image data.

- 3. A method in accordance with claim 2 further com=1 Mt mreshord velues, which companies only erti napreparing: at: plurality.iof: correction look-ups 40 tables with respect to a plurality of combinations of the screen ruling: the screen angle, the resolution of the pixels, and the offset, said plurality of correction look-up tables being adaptable to be used to: performs said recorrecting eat said step (c); and 45 wherein I is a chortest time, and Tancard as is indirectly - wsaid step (c) includes the steps of The year m assi selecting one of the plurality of corrections look-up tables according to the offset; and it was group correcting one of the multi-tone image data. 50 and the threshold value based on the selected correction-look-up tables.nothant מפרכיין עמלי בי ורי פ producing a view display imaspon, in the
- 4. A method in accordance with claim 2; wherein said step (a) further comprises the step of:

 preparing a plurality of corrected threshold matrices with respect to a plurality of combinations of the screen ruling, the screen angle; the resolution of the pixels, and the effset; and wherein

- selecting one of the plurality of corrected threshold matrices according to the offset; and the matrices according to the offset; and the matrices according to the offset; and the matrix reading out a corrected threshold walue from the corrected threshold matrix thus selected.
- 5. A method in accordance with claim 1, wherein said desired halftone dot percent corresponding to multi-tone image data to is given by M(lo)Mt, where M(lo) denotes the number of pixels to form the halftone dot in said each halftone dot area, and Mt denotes a total number of pixels in one halftone dot area.

 Wherein said step (a) includes the step of
 - wherein said step (a) includes the step of:

 "Correcting the multi-fone image data to be greater than an M(lo)-th lowest value among Mt threshold values corresponding to Mt pixels existing in said each halffone dot area.
- unit 70 of Fig. 2u. The SPM unit 190 includes flory Arrapparatus for comparing multi-terre image dataes to with a threshold value to generate a halffone amage 30% signal representing an on/off state of each of pixels arranged in lattices on an image plane, and ferming: 237 ashalftonesdotsin vesponse to said halftone image sees signal in each halftone dot area which is repeatedly was arranged to form an array of halftone dot areas on wool the image plane, said apparatus comprising 98 ed. mont themia threshold memory for storing the threshold mem value representing a shape of a malfone dotwone according to an image idensity, and in unorthrough to sluck time acorrection imeans if for a correcting at a least does either of the multi-tone image data and the threshold value so that a halftone dot is formed in said : 221 each halftone dot area to have a desired halftone elast dot percent specified by the multi-tone image data. At 1500 thi eshola marices. 1,3
- Arrapparatusin accordance with claim 7; wherein it is said correction means comprises: A second of second

5

10

15

said each halftone dot area from the pixel lattices;

correction executing means for correcting at least either of the multi-tone image data and the threshold value according to said offset.

An apparatus in accordance with claim 8, wherein the correction executing means comprises:

look-up table preparation means for preparing a plurality of correction look-up tables with respect to a plurality of combinations of the screen ruling, the screen angle, the resolution of the pixels, and the offset, said plurality of correction look-up tables being adaptable to be used to correct the multi-tone image data;

selection means for selecting one of said plurality of correction look-up tables according to the offset calculated by the offset calculating means; and

means for correcting the multi-tone image data based on the correction look-up table selected by the selection means.

10. An apparatus in accordance with claim 9, wherein

said desired halftone dot percent corresponding to multi-tone image data lo is given by M(lo)/Mt, where M(lo) denotes the number of pixels to form the halftone dot in said each halftone dot area, and Mt denotes a total number of pixels in one halftone dot area; and wherein

said look-up table preparation means includes:

means for obtaining corrected multi-tone image data Ic for each of the multi-tone image data Io, the corrected multi-tone image data Ic being set to be greater than an M(Io)-th lowest value among Mt threshold value corresponding to Mt pixels existing in said each halftone dot area; and

means for registering relations between the multi-tone image data lo and the corrected multi-tone image data lc into said plurality of correction look-up tables.

11. An apparatus in accordance with claim 8, wherein the correction executing means comprises:

look-up table preparation means for preparing a plurality of correction look-up tables with respect to a plurality of combinations of the screen ruling, the screen angle, the resolution of the pixels, and the offset, said plurality of correction look-up tables being adaptable to be used to correct the threshold value;

selection means for selecting one of said plurality of correction look-up tables according to the offset calculated by the offset calculating means; and

means for correcting the threshold value based on the correction look-up table selected by the selection means. 12. An apparatus in accordance with claim 11, wherein special desired halftone dots percent corresponding to multi-tone image data loss given by M(lo)/Mt; where M(lo) denotes the number of pixels to form the halftone dot in said each halftone dot area, and Mt-denotes a total number of pixels in one halftone dot area; and wherein

resaid relook-up table preparation means includes:

means for determining corrected threshold values by setting the lowest through an M(lo)-th lowest values among Mt threshold values corresponding to Mt pixels existing in said each halftone dot area to be less than the multi-tone image data lo; and

means for registering relations between the multi-tone image data lo and the corrected threshold value into said plurality of correction look-up tables.

13. An apparatus in accordance with claim 7, wherein said correction means further comprises:

offset calculating means for determining an offset for said each halftone dot area including a subject pixel to be processed, as a function of a resolution of the pixels as well as a screen ruling and a screen angle which define the array of halftone dot areas on the image plane, said offset representing a deviation of a predetermined reference point of said each halftone dot area from the pixel lattices:

matrix preparation means for preparing a plurality of corrected threshold matrices for a plurality of combinations of the screen ruling, the screen angle, the resolution of the pixels, and the offset, said plurality of corrected threshold matrices being stored in said threshold memory and adaptable to be compared with the multi-tone image data so that a halftone dot is formed in said each halftone dot area to have a desired halftone dot percent specified by the multi-tone image data;

selection means for selecting one of said plurality of corrected threshold matrices according to the offset calculated by the offset calculating means;

means for reading out a corrected threshold value from the threshold memory selected by the selection means; and

comparison means for comparing the corrected threshold value read out from the selected corrected threshold matrix with the multi-tone image data, thereby generating the halftone image signal.

14. An apparatus in accordance with daim 13, wherein said desired halftone dot percent corresponding to multi-tone image data to is given by M(Io)/Mt, where M(Io) denotes the number of pixels to form the halftone dot in said each halftone dot area, and Mt denotes a total number of pixels in one

45

55

15

ය වේ. අතර අතර ගත්ත වෙන්න වෙන්න වෙන්න වෙන්න වෙන්න කිරීමට ඇත. මෙන්

fings in the and call bear politicative bookies of a off will a linguage configuration to render to seleterations of goods cardies levi discrease to

An abjuirable maccordan with ability 8 what obtain 8 what to consider the consider of the consider of the consider was a second to the considering a piletity or consection lookings takes with a sequent to a bilitatiny of combinations of the scream or the considering of the considering of the considering that according to the considering of the consideri

Selection (leans on selecting one of said on rethin of octrehelm pokins settles accounting to the offent obsolutes of me offers calculating means and

meand for updating the multi-tune image data has been on the content of took-up table inferred to the selection means.

16. In apparais in accordance with rising 9, wherein general desiract halfone dot percent corresponds to multi-tone image data to is given by the (logified, where M(ic) denotes the rumber of picels to darn the halfone dot in said each halfone dot creased Mt denotes a total number of pixels in one halfone dot area, and wherein

said look-up table preparation means inclupes:

in means for obtaining corrected multi-tone image data to for each of the multi-tone image data to, "the currected multi-tone image data to being set to being set to being set to being reaser than an IA(to)-th lowest value among that thi senoid value corresponding to Mt pixels existing in said each halitone dot area, and

means for registering relations between the multi-tions image data to aird the pon sused multi-tione image data to it to said pluratific of correction looker bitables.

11. An apparatus in accordance with claim 1 whe am are corrected, executing means for present the area corrected and in additional series and the area corrected a corrected and corrected and corrected and area corrected and the corrected and area corrected and area corrected and areas corrected and areas corrected and areas.

Set potion in sense or accessing one of such planes, or connection cock-or tables so accessing to the present of accessing or or other productions of the movement and accessing to the contractions.

chealing for compatible (19) to an old a little season of a control of the contro

halftone dot area; and wherein the autimatique of the comprises:

23 33

means for correcting the lowest through an M(lo)-th lowest values among Mt threshold values corresponding to Mt pixels existing in Said each halftone dot area to be less than the multi-tone image data lo, to thereby obtain corrected threshold values to be stored in said plurality of corrected threshold matrices.

recursifications of casterial by visit managed to the control of t

 An application in accordance, with discult increasing tail on adjoing manage wither comprises.

The property of search provided the property of the property o

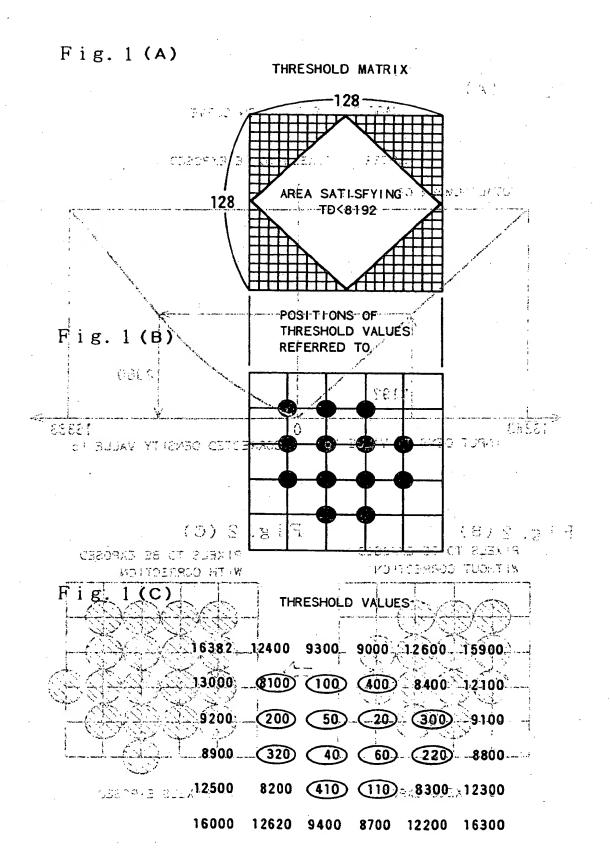
a matrix prevared in maeric preparing a punction prevail, of someoted in schold matrices of a punction plantally of someoted in the scholar matrice, we suresh angle. The resolution of the phasis, and the offset, and plantally of comented incarrold metric policy said plantally of comented income and adapted in a some adapted in a compared with the mutitone image cotte actions a national total actions of a compared on the former in acid each institute of the second and per entities a deserval matrices at per entities of the mutitone cate per entitle of the mutitone categories.

sensotium in a to selecting on a condition of a condition of the align of memory sector fing to the other or detail of the align or ducting means.

todung, which wo have growers to them. 45 and yours for them to the state of them.

ប្រជាពល ប្រធានប្រជាពលគេ ប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប ប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប ប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រធានប្រ

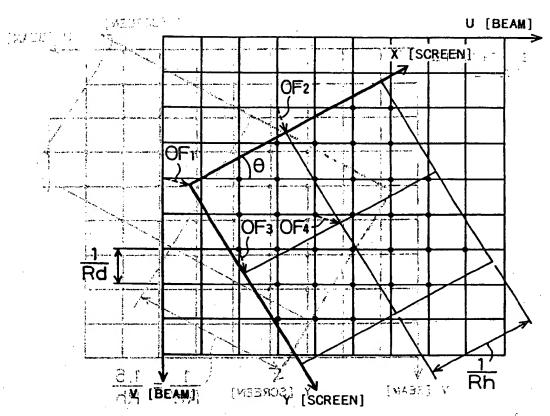
Fig. 45 (1) This Later Enter Committee (1997) And African Committee (1997)



LIPSTAN GLICHER -1 Fig. 2 (A) IMAGE DATA CORRECTION CURVE NUMBER OF PIXELSTO BE EXPOSED TOTAL NUMBER OF PIXELS ALL AND REFERRED 8900 8192 16383 16383 INPUT DENSITY VACUE CORRECTED DENSITY VALUE IC Flig. Fig. 2 (B) 2 (C) PIXELS TO BE-EXPOSED PIXELS TO BE EXPOSED WITHOUT CORRECTION WITH CORRECTION THRESHOL 00:6 6075 13EPIXELSE EXPOSED / 11 0008 18 PIXELS EXPOSED

16000 12800 9401 0700 2204 ... 300

Fig. 3



EXAMPLE WITH VARIED SOLVED TO SCREEN ANGLE #

8 .p 1 %

Fig. 5

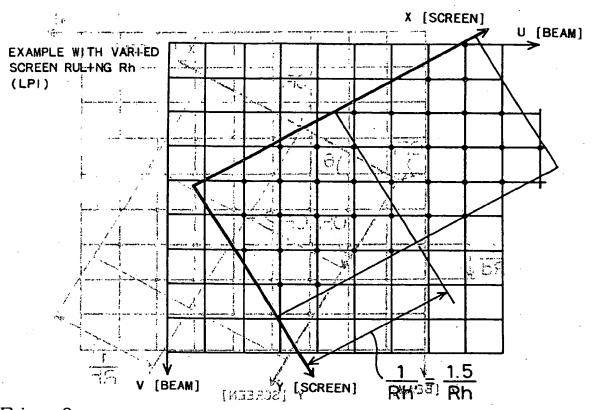
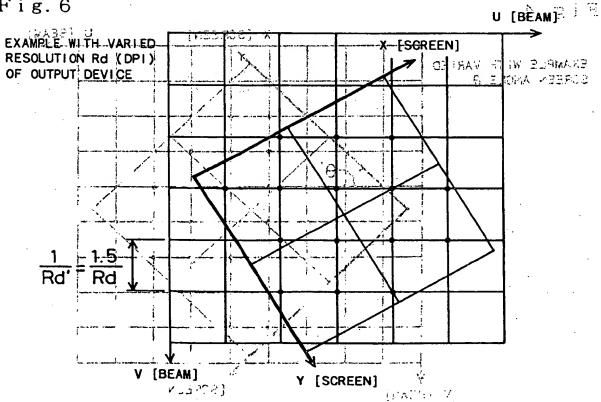
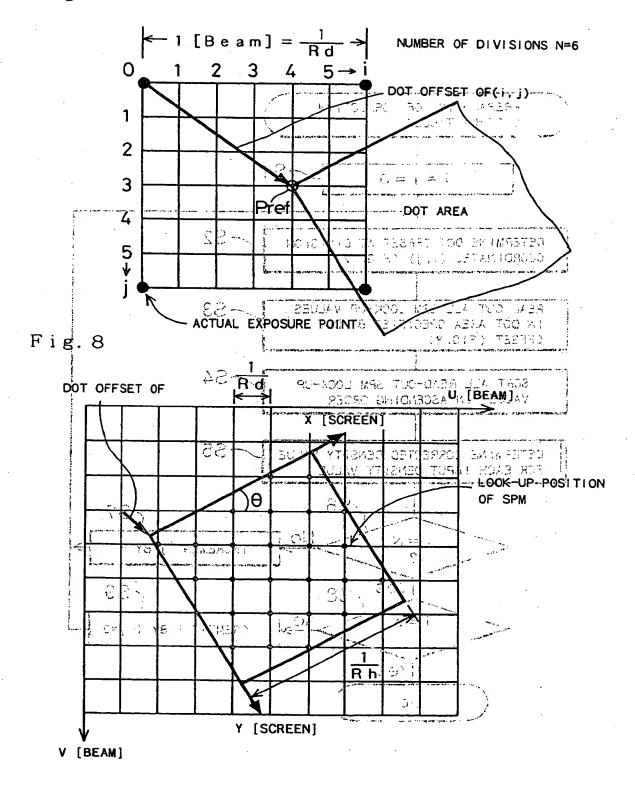


Fig. 6

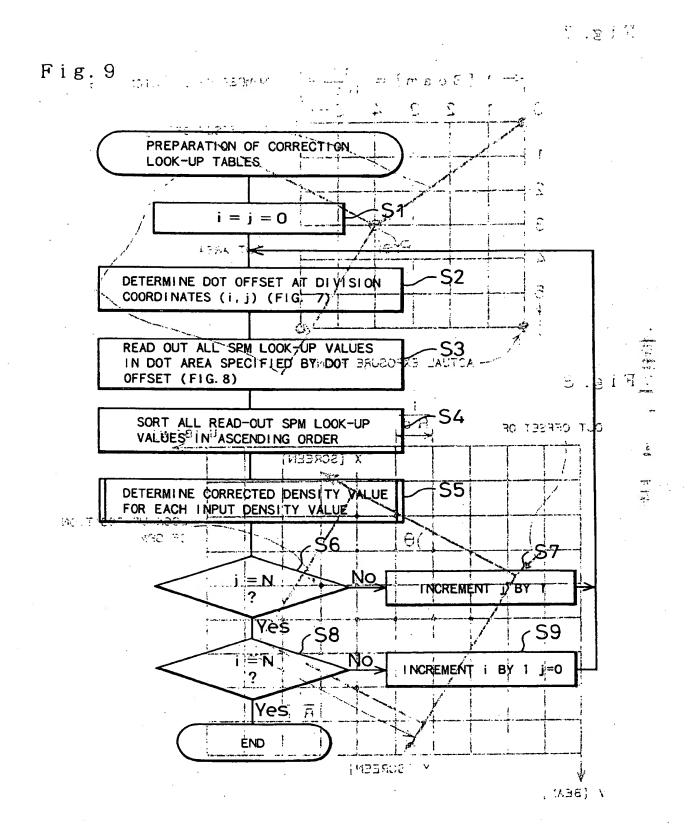


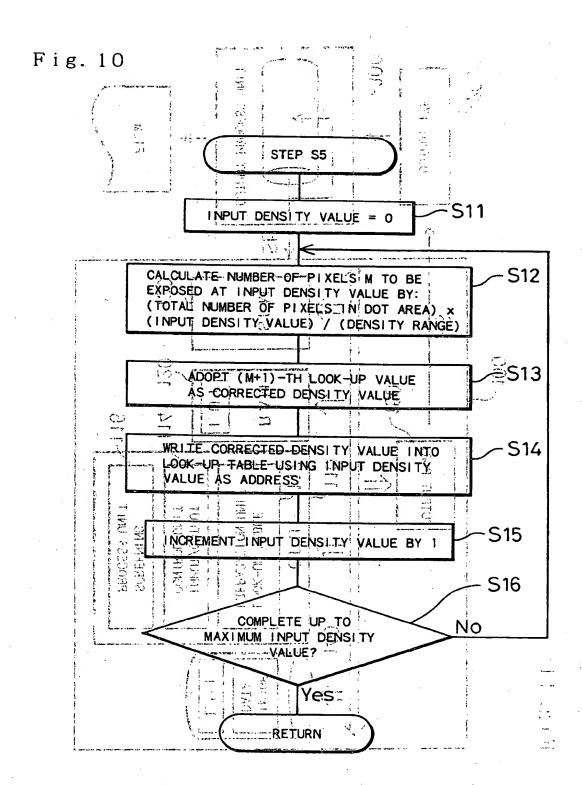
EP 0 731 597 A2

Fig. 7

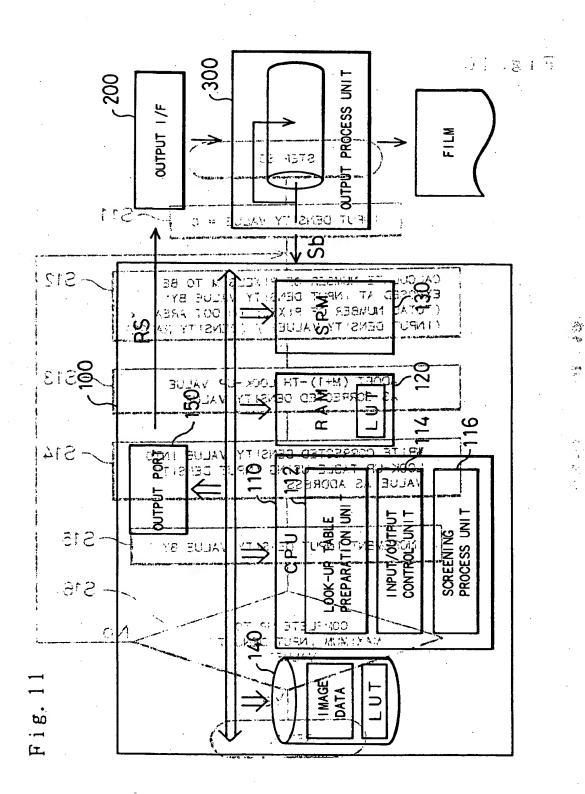


EP.0.7311597.A2:





EP-0 731 597 A2



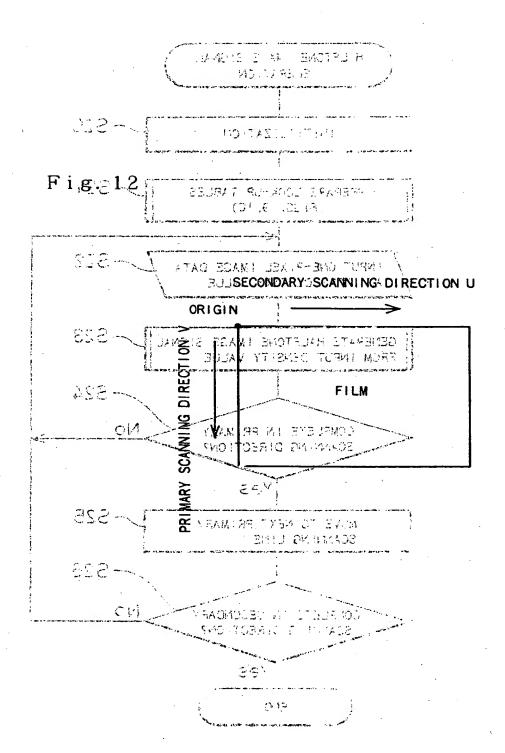


Fig. 13

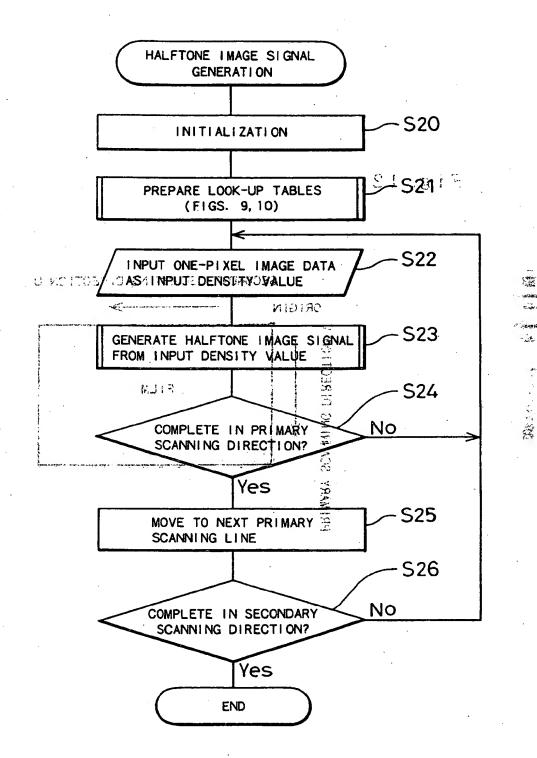
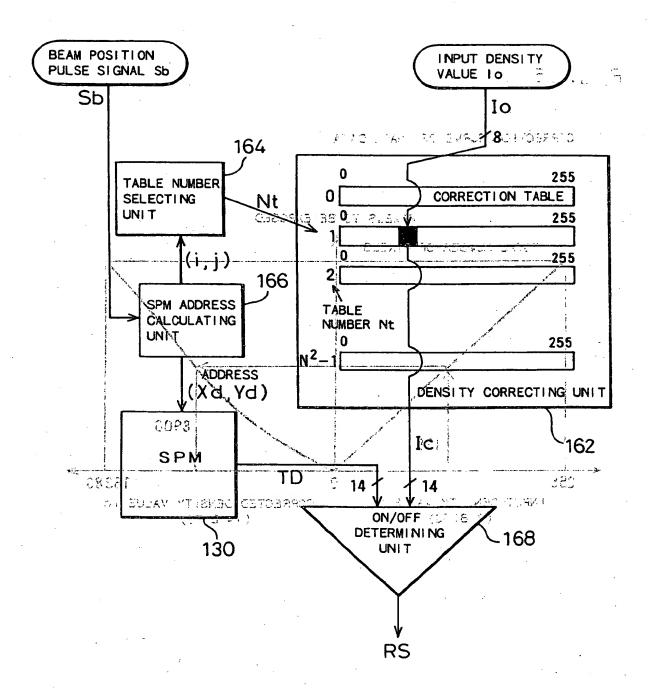


Fig. 14



EP-0731/597-A2

"1 第1円

BEW POSTION 7.90 PULLE STONAL SO Fig. 15 BUJAV **○**! CORRECTION CURVE OF IMAGE DATA 161 255 TABLE INUMERS EJEAT MC TOERSCO SELECTING PIXELS TO BE EXPOSED 265 166 SPM ADDRESS **CULATING** NUMBER NI 223930 (bY TY CORRECTING UT 8900 29 128 SPA 255 A : 1 0 16383 CORRECTED DENSITY VALUE IC INPUT DENSITY YAL'UE LO (8 BITS) RICKED DATE DATE (14"8tTS) 891 000 _ =

US TELPHATES (XELL) Fig. 16 vo text . STEP S23 S31 UPDATE SCREEN COORDINATES (X, Y) IN PRIMARY SCANNING DIRECTION AND DETERMINE SPM ADDRESS (Xd, Yd) AND DOT AREA COORDINATES (XI, YI) S32 READ SPM DATA AT UPDATED SPM ADDRESS No DOT AREA COORDINATES ARE REVISED? (B) (1 SHOW / JORESS (Xd, Yd) Yes [MAJE] U -E-MSRE-CALCULATE TABLE NUMBER (% RO 1 S35 READ CORRECTED DENSITY VALUE CORRESPONDING TO INPUT DENSITY VALUE FROM LOOK-UP TABLE SPECIFIED BY TABLE NUMBER **S36** COMPARE CORRECTED DENSITY VALUE WITH LOOK-UP VALUES TO GENERATE HALFTONE IMAGE SIGNAL END

(扩充) 下海络 退船上围机

Fig. 17 (A)

DOT AREA COORDINATES (XI, YI)

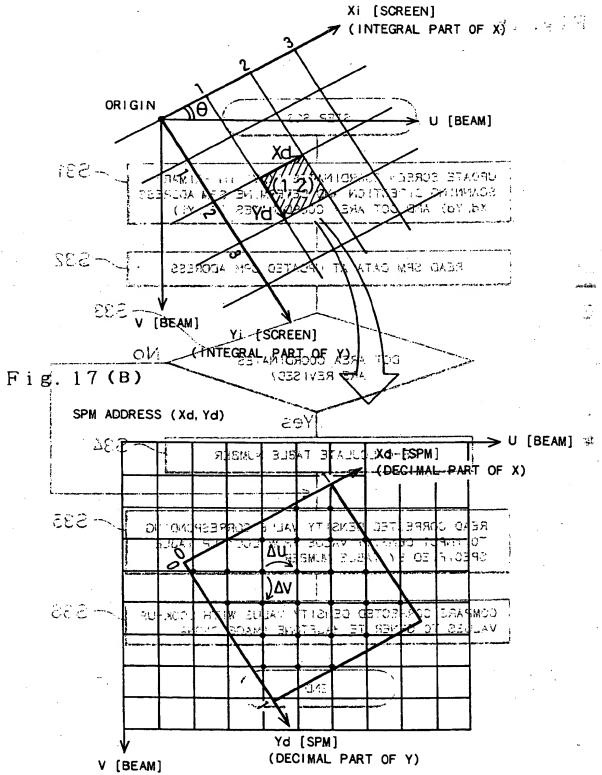
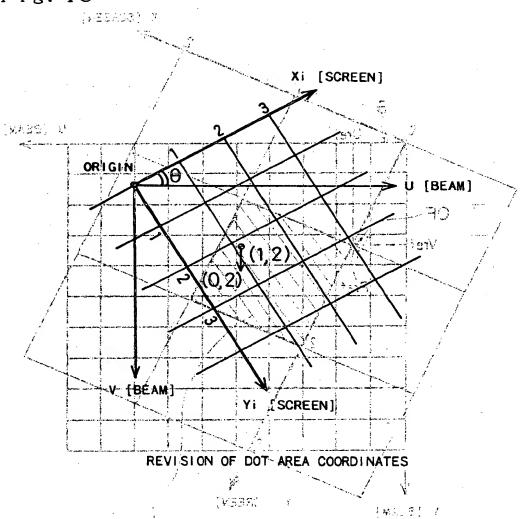


Fig. 18



US NAPA STOO 9 ED 27 COT ARRA DUSSONMATES (71 71)+(0,1)

Fig. 19

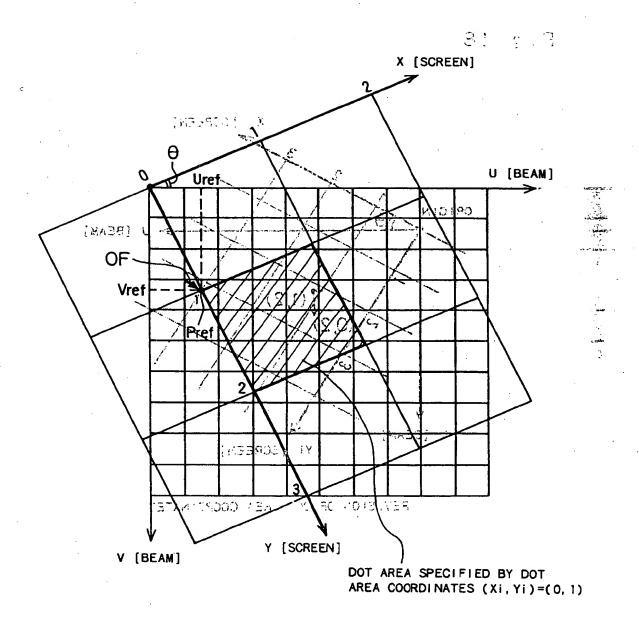
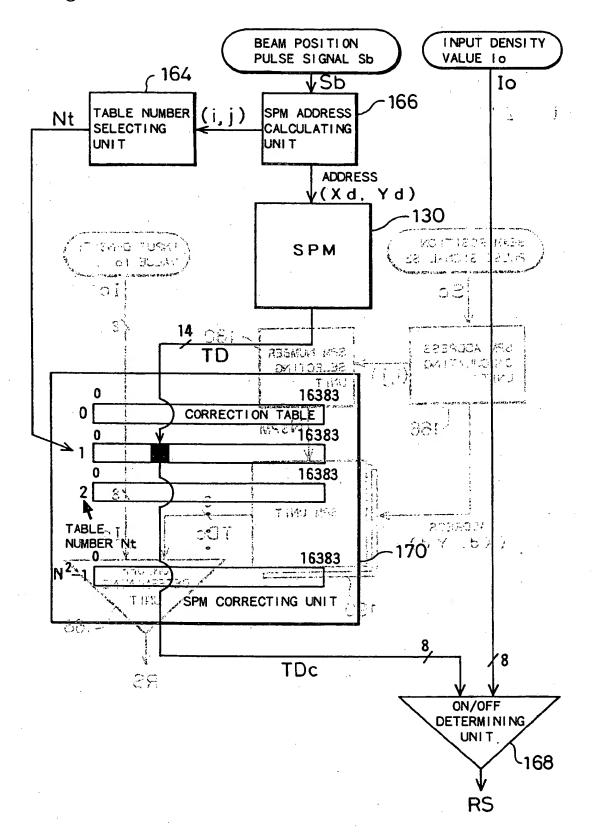
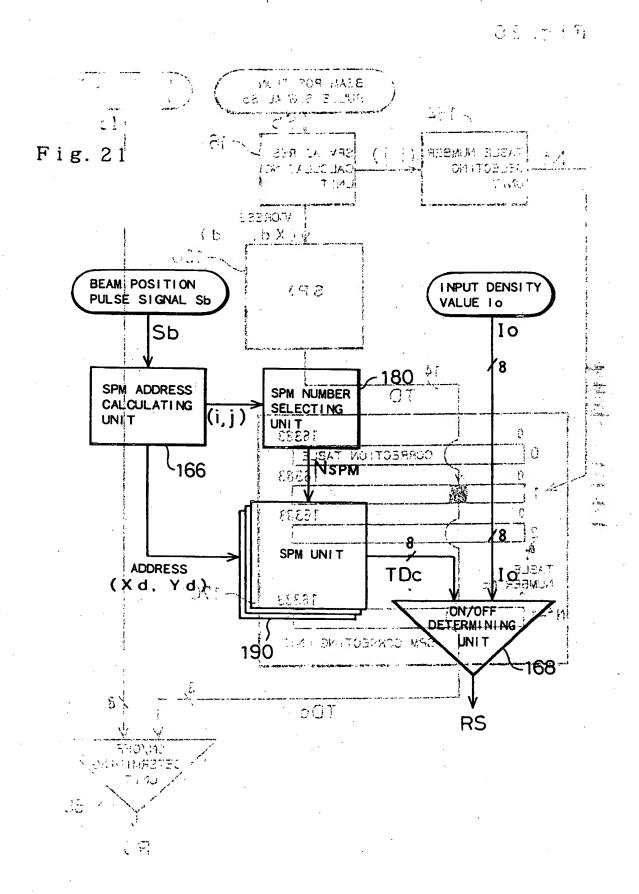
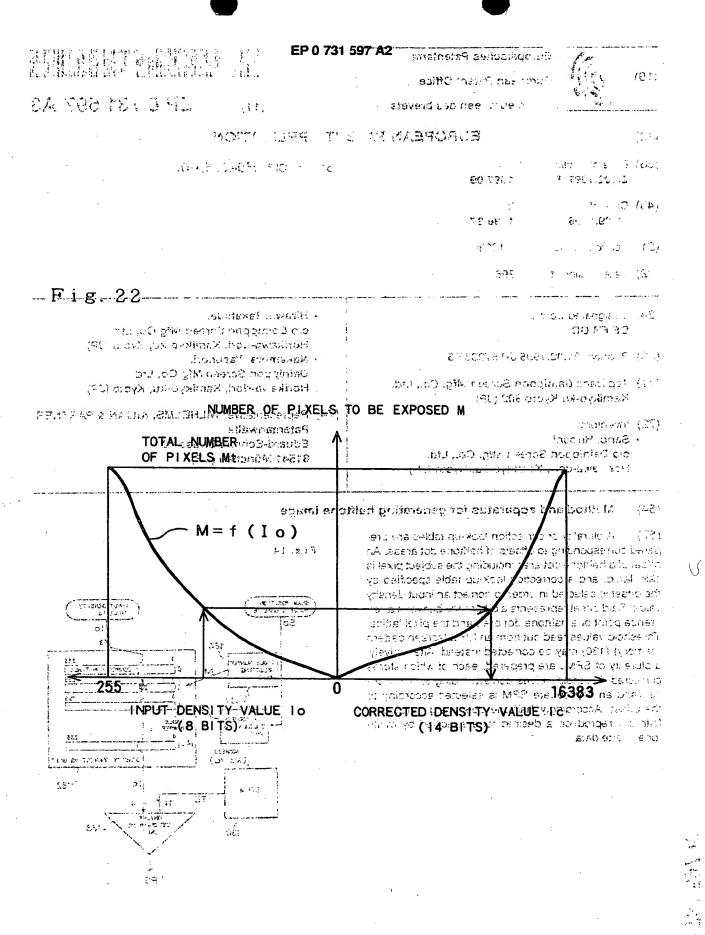


Fig. 20



EP 00731 597 A2





32

(19)

Europäisches Patentamt

European Patent Office

Office européen des brevets



(11) **EP 0 731 597 A3**

(12)

EUROPEAN PATENT APPLICATION

11,7 1,731 691 az

(88) Date of publication A3: 26.02.1997 Bulletin 1997/09

(51) Int. Cl.⁶: **H04N 1/405**

(43) Date of publication A2: 11.09.1996 Bulletin 1996/37

(21) Application number: 96102365.2

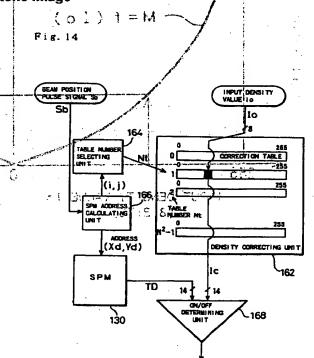
(22) Date of filing: 16.02.1996

- (84) Designated Contracting States: **DE FR GB**
- (30) Priority: 21.02.1995 JP 57933/95
- (71) Applicant: Dainippon Screen Mfg. Co., Ltd.
 Kamikyo-ku Kyoto 602 (JP)
- (72) Inventors:
 - Sano, Hiroshi,
 c/o Dainippon Screen Mfg. Co., Ltd.
 Horikawa-deri, Kamikyo-ku, Kyeto (JP)

- Hirawa, Takahide,
 c/o Dainippon Screen Mfg Co, Ltd
 Horikawa-dori, Kamikyo-ku, Kyoto (JP)
- Nakamura, Yasunori,
 Dainippon Screen Mfg Co, Ltd
 Horikawa-dori, Kamikyo-ku, Kyoto (JP)
- (74) Representative: WILHELMS, KILIAN & PARTNER
 Patentanwälte
 Eduard-Schmid-Strasse 2 3 81541 München (DE) 2 9 30

(54) Method and apparatus for generating halftone image

(57)A plurality of correction look-up tables are prepared corresponding to offsets of halftone dot areas. An offset of a halftone dot area including the subject pixel is calculated, and a correction look-up table specified by the offset is selected in order to correct an input density value. Said offset represents a difference between a reference point of a halftone dot area and the pixel lattice. Threshold values read out from an SPM (screen pattern memory) (130) may be corrected instead. Alternatively, a plurality of SPMs are prepared, each of which stores corrected threshold values corresponding to each offset, and an appropriate SPM is selected according to the offset. Accordingly, halftone dots are generated to faithfully reproduce a desired tone specified by multitone image data.





EUROPEAN SEARCH REPORT:

EP 96 10 2365

i,

Europe Charles Palaciants

	Citation of document with indication, where appropriate, of relevant passages		Relevant to claim:	CLASSIFICATION OF THE APPLICATION (Inc. CL6)
	Electronic Imagi		1,7	H04N1/405
	1986,	ERLAG, Berlin (DE)		
	XP002020421	NA		736.
١		215 3850	11	
	*	graph B - page 167,	line 4	. Professional
		d) leunost 01-80-47		61 (01.
(1.5	EP-A-0 334 518 (1,7	Lora et Domiseum Berse
	* column 12, lin	e 36 - 11ne 58 * e 16 - 2610mm 21 - 15	ne 13	: Li sli i - xo so no ssi
		e 16 - cofumn 21, li		
195 V t	Ray Paul Ca Agio Ca			Carpert ACC SANGER ABOUT
	* page 6, line 1	EASTMAN KODAK COMPAN 3 - line:54 = 1	Y) 2,3,8,9	Tildae cocke
	* page 16, line			.93 at 140 Mass
	EP-A-0 141 869	T leseroth 9485-8 DRING. RUDOLF HELL	GMBH). 4. 13.	a service and another
	* page 13, line	4 - line 20 *	را مروس والماري والمارية	
			,	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
	solution.	ing r <mark>estric</mark> ted abhaity res	van ediveb g.r. at	H04N
Har⊕i	r dunca wetska dupe	sega un a carriar by a rend	ra ilg to Opti ətəlci	en all watered a best in
(₽30.17. 195≅	7 (* 095 00607 9 2: (* avar - 3544 avar - 5	binary rendering seconders	a tir o pasmigris Sano-etti santari	derbe inspendik dibender in Herre ingo dobistan servici
di itar	สถอน เลดอส์ / สเลออส	obtain medictable results a	o et autori de deserva	rk 1 €u 18 - k 3 ± 3 - 10€37
sie A	massys principres et	the density east plan of t	inheus er to eeu-	the macrossings of
511.5	n coltatosen reliada or	mos qui gnivigi (di sessentin	CIN TO DO ATRICICATION	त्र प्रशास कार स्टब्स है है। १९ इस सह
		in the second se		
		2.3		
		neprime and in		
				1
	·			;
·····	2			
		has been drawn up for all claims		
	Place of search	has been drawn up for all claims Date of completies of it	search	Examines
	Place of search THE HAGUE	bas been drawn up for all claims Date of completies of it 9 December	1996 De	Roeck, A
X: 122	Place of search	bas been drawn up for all claims Date of completion of the second secon	search	Roeck, A